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Some current observations and surface T/S distribution from the Scotia Sea and the Bransfield Strait during early austral summer 1980/81

by

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With 12 figures and 1 table

Einige Strömungsbeobachtungen und die T/S-Verteilung an der Oberfläche aus der Scotia See und der Bransfield Straße im frühen Südsommer 1980/81

Zusammenfassung

Es werden Daten von zwei Strommesserverankerungen und Thermosalinographen-Aufzeichnungen aus der Scotia See vorgestellt. Die Ergebnisse des ersten Verankerungsortes stellen den Austausch von antarktischem Bodenwasser zwischen Scotia See und Argentinischem Becken dar. Der zweite Strommesserdatensatz zeigt den permanenten tiefen Gegenstrom am Kontinentalabfall der südlichen Drake-Straße. Die Registrierungen der Oberflächentemperatur und des -salzgehaltes beschreiben die Lage der Polarfront und der Weddell-Scotia-Konfluenz im frühen Südsommer 1980/81.

Summary

Data from two current meter moorings and thermosalinograph records from the Scotia Sea are presented. Results from the first mooring site demonstrate the exchange of Antarctic Bottom Water between the northern Scotia Sea and the Argentine Basin. The second current data set illustrates the permanent deep counter current on the continental rise of the southern Drake Passage. Surface temperature and salinity records describe the position of the Polar Front and the Weddell-Scotia-Confluence during early austral summer 1980/81.

Introduction

As part of the long term project Biological Investigation of Marine Antarctic Systems and Stocks (BIOMASS) R.V. "Meteor" operated in the Scotia Sea and the Bransfield Strait during austral summer 1980/81. Among the hydrographic data sets from the first (ANT I) and second (ANT II) leg of the cruise (November—January) are observations from two mooring sites and the thermosalinograph record from surface waters, collected continuously while the ship was under way. Similar surface observations from the Weddell-Scotia-Confluence in February 1981 have been compiled by Stein (1981). For logistical details of "Meteor" Cruise 56 in antarctic regions the reader is referred to the cruise reports (cf. Zeitzschel & Zenk 1981). The cruise tracks ANT I and ANT II are displayed in Fig. 1.

Current meter observations

Firstly we present observational results from two different current meter moorings which were located in the Scotia Sea. In addition to the current meters both moorings were equipped with numerous chemical samples for the study of dissolution of biogenic carbonates. The main purpose of mooring 259 was to monitor near bottom water transport west of the Shag Rocks between the Scotia Sea and the Argentine Basin. The depth at its position 52° 52′ S, 48° 19′ W was 3008 m. Two current meters 35 and 85 m above the bottom were deployed by R.V. "Polarsirkel" on 23 December 1979 on a supply cruise to Antarctica. Recovery by R.V. "Meteor" took place on 19 November 1980. A first interpretation based on the near bot-

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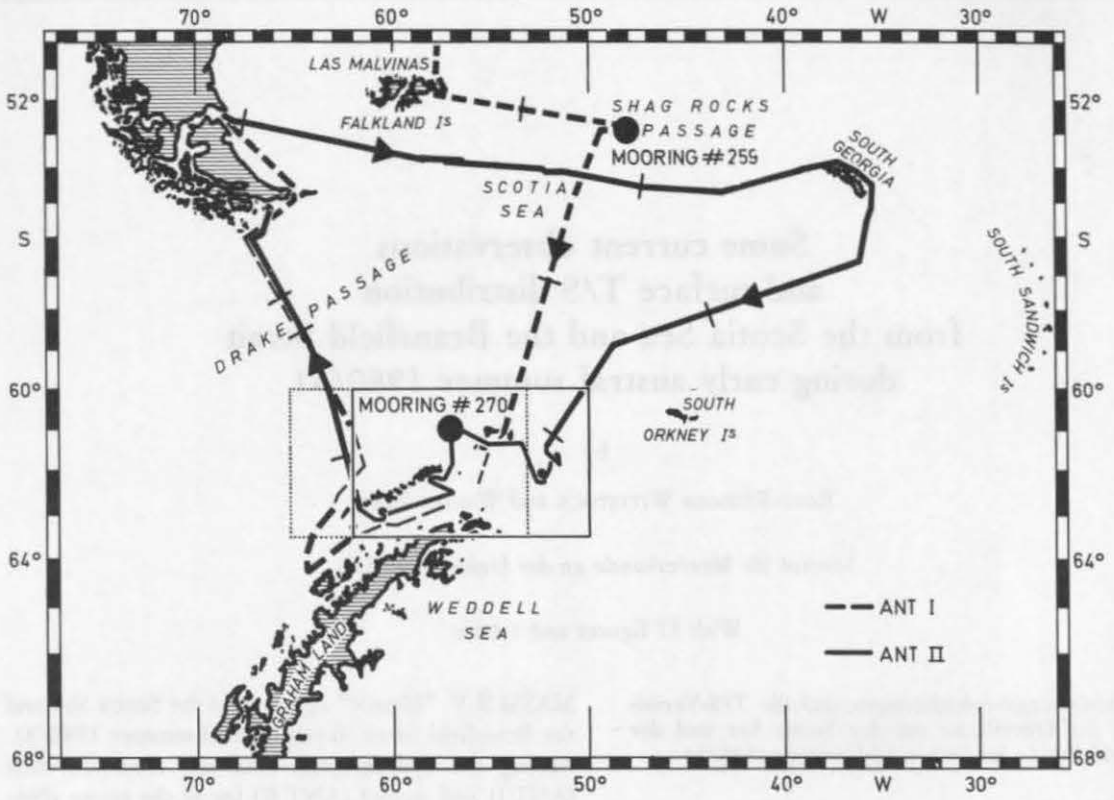

Fig. 1. Cruise tracks ANT I and ANT II of R.V. "Meteor" during austral summer 1980/81.

Abb. 1. Kurse ANT I und ANT II des F.S. „Meteor" im Südsommer 1980/81.

tom current meter has been given by ZENK (1981). Here we present the edited data only.

Mooring 270 was situated on the continental rise of the southern side of the Drake Passage (60° 54.6' S, 57° 06.0' W) approximately 110 km north of King George Island (3625 m depth). Its primary objective was a test of the depth dependent dissolution of carbonates under antarctic conditions. In addition a number of sediment traps were distributed over the whole water column (WEFER et al. 1982). We took the unique opportunity of this moored "platform" to deploy 4 current meters of which 3 in the depth of 439, 1489 and 3621 m have yielded data sets. Mooring 270 was deployed from 2 December 1980 until 21 January 1981. At both current meter sites hydrographic observations were performed. As background information they are shown — in case of mooring 270 together with the instrument distribution — in Fig. 2 a and 2 b. The CTD-data were obtained using the Kieler Multisonde (see KROEBEL & RATHLEV in ZEITZSCHEL & ZENK 1981).

All current meter data were obtained using Aanderaa instruments. The tapes were routinely processed in Kiel as described by KÄSE et al. (1978).

Different graphical presentations of the current meter records were chosen (Figs. 3—8). The progressive vector diagrams of 259 (Fig. 3) first were turned by 75° in a way which lets the along channel component of the near bottom current point positive upwards. In the equivalent graph from 270 the north direction points upwards in the conventional manner. Stick plots of the current vectors are displayed in Figs. 5 and 6. Prior to plotting the current vector series 259 was rotated as described before. Figs. 7 and 8 represent the time series of temperature, salinity (where available) and current components in polar co-ordinates. Basic statistics of the current observations are summarized in Table 1.

Surface T/S distribution

Secondly we present temperature/salinity (T/S) data from surface waters in the Scotia Sea and the Bransfield Strait. They were collected continuously with a Plessey thermosalinograph. The water was sampled from about 2 m below the surface by the ship's scientific sea water pipeline system. The thermometer was mounted in the centre well 1 m below the surface. The quality of thermosalinograph data was controlled by comparisons with multisonde stations. In addition 66 surface water probes were analysed. The standard de-

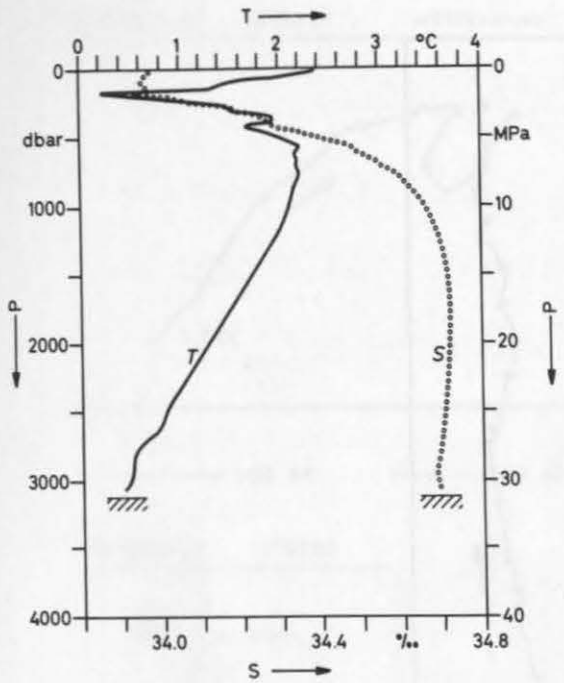

Fig. 2 a. Vertical temperature and salinity profiles from the Shag Rocks Passage (52° 52.1′ S, 48° 17.4′ W) near mooring position 259.

Abb. 2 a. Vertikale Temperatur- und Salzgehaltsprofile in der Shag Rocks-Passage (52° 52,1′ S, 48° 17,4′ W) bei Verankerungsposition 259.

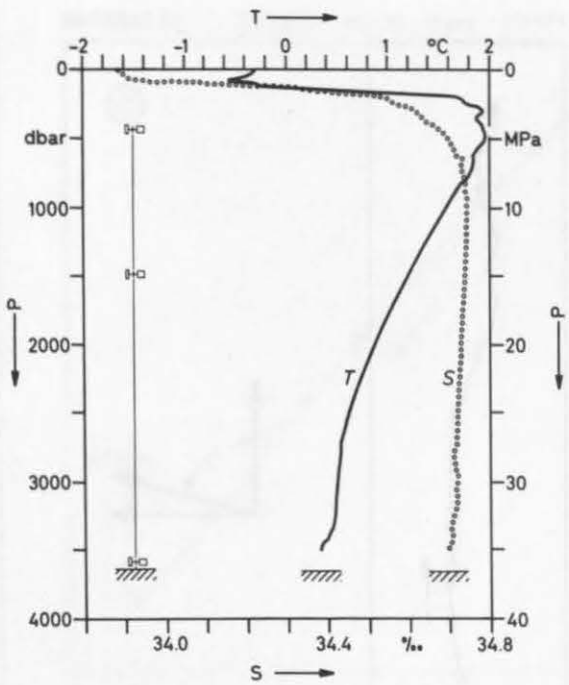

Fig. 2 b. Vertical temperature and salinity profiles at 60° 53.8′ S, 57° 06.6′ W, southern Drake Passage near mooring position 270. Current meter levels are indicated by symbols.

Abb. 2 b. Vertikale Temperatur- und Salzgehaltsprofile bei 60° 53,8′ S, 57° 06,6′ W in der südlichen Drake-Straße nahe der Verankerungsposition 270. Die Tiefenlagen der Strommesser sind durch Symbole angedeutet.

Table 1. Statistics of time series from moorings no. 259 (Shag Rocks Passage) and 270 (southern Drake Passage). u, v represent cartesian current components in east and north direction, T = temperature, S = salinity.

Tabelle 1. Statistik der Zeitreihen aus den Verankerungen Nr. 259 (Shag Rocks-Passage) und 270 (südliche Drake-Straße). u, v symbolisieren kartesische Strömungskomponenten in Ost- bzw. Südrichtung, T = Temperatur, S = Salzgehalt.

ref no	parameter	depth (m)	min	max	mean	std dev	vector mean	mean dir (°TC)
259102	u (cm s^{-1})	2923	−71.06	29.78	−16.47	16.09	16.9	283
	v (cm s^{-1})		−42.54	42.16	3.69	10.03		
	T (°C)		0.13	1.36	0.58	0.181		
259103	u	2973	−65.17	30.96	−16.07	15.28	17.2	291
	v		−42.35	45.02	0.61	11.11		
	T		0.11	1.26	0.52	0.164		
270102	u (cm s^{-1})	439	−19.0	23.1	5.8	5.9	6.8	58
	v (cm s^{-1})		−19.6	27.8	3.6	7.8		
	T (°C)		1.20	1.93	1.76	0.086		
	S (‰)		—	—	(34.54)*	0.071		
270105	u	1489	−14.0	16.3	11.3	3.8	18.7	142
	v		−19.8	17.1	−14.9	4.5		
	T		0.94	1.36	1.20	0.091		
270111	u	3590	−32.7	1.40	−14.0	5.8	20.9	222
	v		−28.1	0	−15.5	4.8		
	T		− 0.17	0.13	− 0.02	0.052		

* No adjustment of the recorded salinity was tried. The CTD station in Fig. 2 b shows 34.69 ‰ at the current meter level.

viation of the corrected salinity values was 0.022 ‰ compared against the bottle data. T/S time series were carefully converted into spatial distributions using all available nautical information. We have chosen a track line representation of the surface parameters T and S, because synoptic errors and insufficient regional coverage made isopleth diagrams senseless.

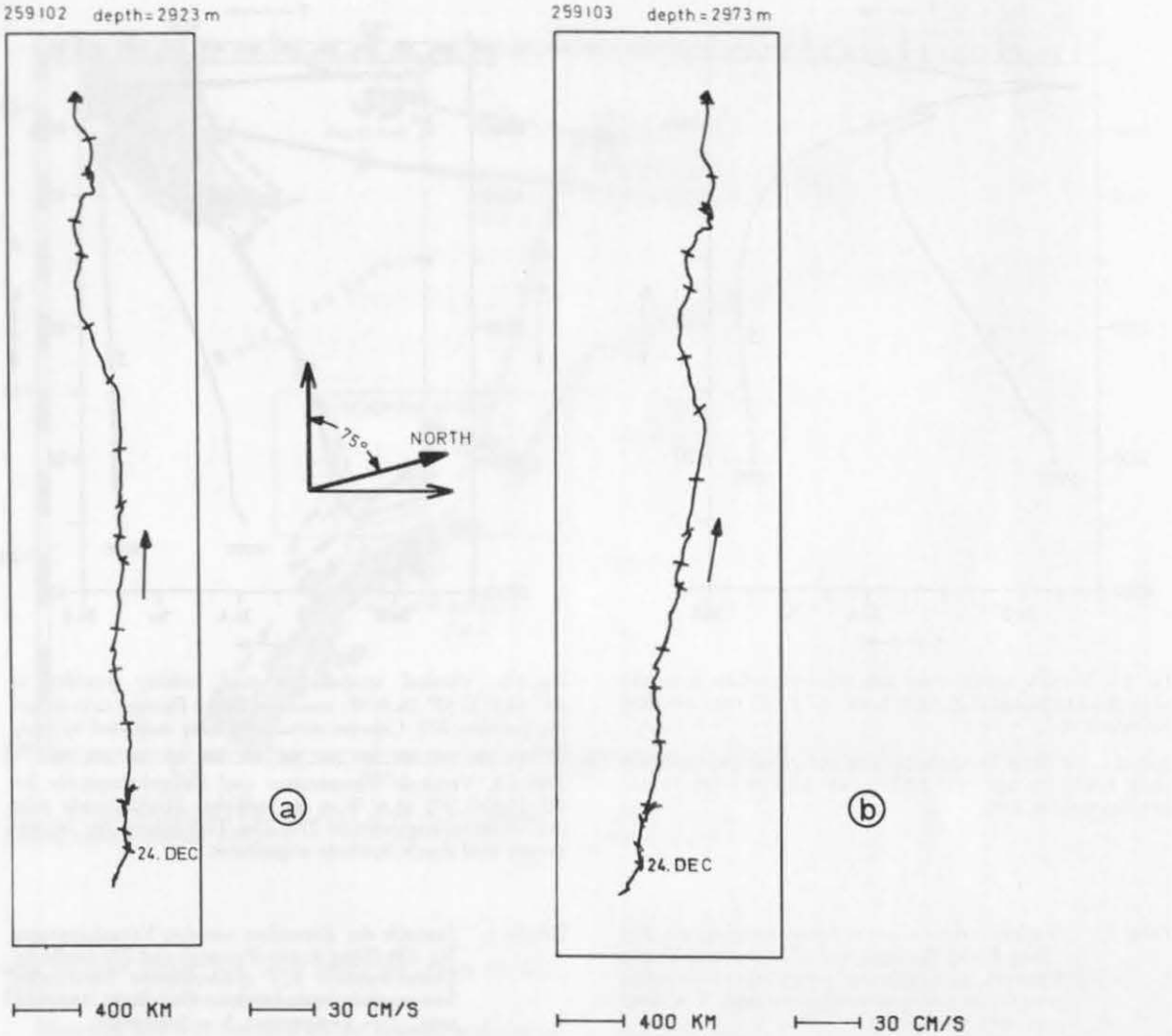

Fig. 3. Progressive vector diagrams from mooring 259, Shag Rocks Passage. 15-day tic marks are included. (a) record from 85 m, (b) from 35 m above the bottom.

Abb. 3. Fortschreitende Vektordiagramme von Verankerung 259, Shag Rocks-Passage. 15tägige Zeitmarken sind eingetragen. (a) Meßreihe 85 m, (b) 35 m Bodenabstand.

In Figs. 9 and 10 we show overview charts from the observed T/S fluctuations during the first (ANT I) and second (ANT II) leg. Close-up salinity diagrams from the Bransfield Strait and the Weddell-Scotia-Confluence are displayed in Fig. 11. Due to technical problems no informative temperature diagram could be produced. Instead in Fig. 11 we have included extreme values of the surface temperature as were encountered on passage through these regions of minimal horizontal temperature gradients. At about 62° 30′ S, 56° 30′ W (insert F in Fig. 11) a small scale frontal study was performed on 10/11 December 1980. A variety of physical, chemical and biological parameters were measured in this box (i.e. chlorophyll concentration by HAARDT & MAASSEN in ZEITZSCHEL & ZENK 1981). Here we show results of the echosounder (Fig. 12 a) and the surface salinity distribution (Fig. 12 b).

Discussion and conclusion

It is the purpose of this report to present a selected hydrographic data set from measurements taken in the Scotia Sea and the Bransfield Strait within the frame work of BIOMASS. The shown aspects of the physical environment may serve as a basis for other investigators in interpreting their findings.

The deep current observations from the Shag Rocks Passage have already contributed to the problem of water exchange between the Scotia Sea and the Argentine Basin (ZENK 1981). It could be shown that intermittent overflow events of cold Antarctic Bottom Water are a characteristic feature for the water renewal in the Argentine Basin.

The main surprise of the southern Drake Passage mooring was the permanent deep current feeding the South Pacific with water masses from the Scotia Sea

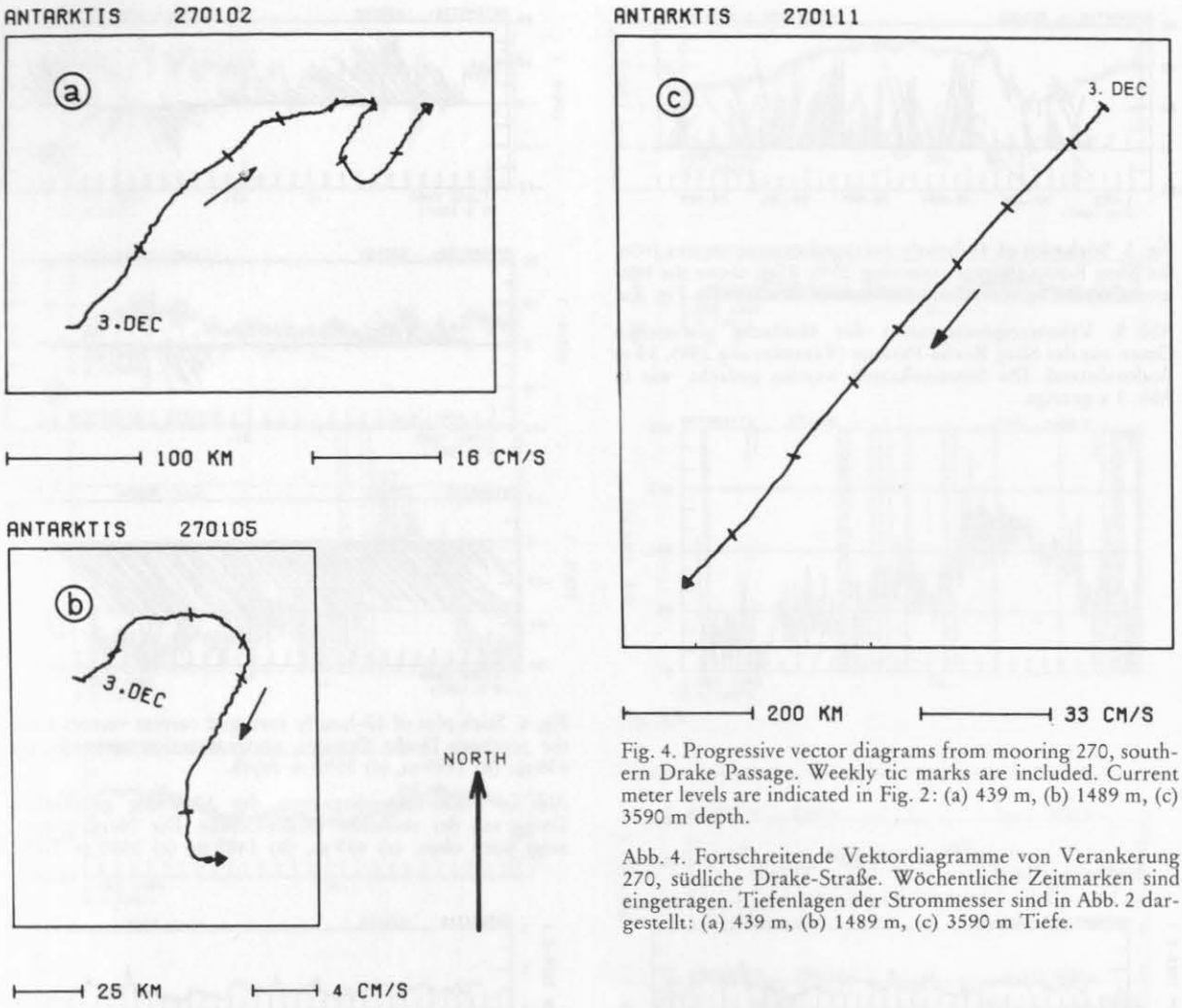

Fig. 4. Progressive vector diagrams from mooring 270, southern Drake Passage. Weekly tic marks are included. Current meter levels are indicated in Fig. 2: (a) 439 m, (b) 1489 m, (c) 3590 m depth.

Abb. 4. Fortschreitende Vektordiagramme von Verankerung 270, südliche Drake-Straße. Wöchentliche Zeitmarken sind eingetragen. Tiefenlagen der Strommesser sind in Abb. 2 dargestellt: (a) 439 m, (b) 1489 m, (c) 3590 m Tiefe.

(Figs. 4 c, 6 c). This stream flows into the opposite direction of the Circumpolar Current and may play a significant role in the transport of krill larvae towards the Bellinghausen Sea. Independent observations conducted by WHITWORTH et al. (1982), 220 km towards the west near Livingston Island, confirm the persistent nature of the counter current.

The surface parameter distribution can often be used as an indicator of frontal zones separating different water masses. On southbound crossings of the Scotia Sea one encounters two significant thermohaline fronts: the Polar Front and the Weddell-Scotia-Confluence. The position of both features during the early austral summer 1980/81 can be obtained from the track line representation. The Polar Front can be seen most clearly in the central Drake Passage at about 58° 30′ S, 63° 30′ W on 14/15 December where dramatic steps of 4.0 °C and 3.2 ‰ were found (Figs. 9 a, 10 a). Indications for possible front meanders in the northern Scotia Sea were found at and south of the Shag Rocks Passage (53° S, 48° W near mooring position 259) on 19/21 November. At approximately the same position the Polar Front again was found on the January leg ANT II. Although summer heating has progressed by the end of January, we still can recognize a surface expression of the polar front at about 60° S, 65° 30′ W in the Drake Passage on the return trip on late 31 January.

Pronounced salinity fluctuations in Figs. 10 b and 11 b indicate the hydrographic transition region between the southern Scotia Sea and the northern Weddell Sea. Crossings of this Weddell-Scotia-Confluence took place roughly on 61° S several times on 17, and between 24 and 26 January. This observation is consistent with STEIN's data analysis (1981) from February 1981.

Acknowledgements

This work has been supported by the Deutsche Forschungsgemeinschaft, Bonn. The thermosalinograph used was liberally lent by Dr. PRAHM-RODEWALD. From Dr. ROETHER's laboratory we obtained the salinometer check values. A. KUHL helped us in the data reduction state. This is contribution number 400 of the Joint Research Project SFB 95 at Kiel University.

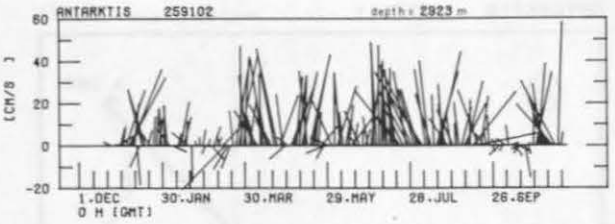

Fig. 5. Stick plot of 48-hourly averaged current vectors from the Shag Rocks Passage (mooring 259), 85 m above the bottom. Current vectors have been rotated as shown in Fig. 3 a.

Abb. 5. Vektorzeigerdiagramm der 48stündig gemittelten Daten aus der Shag Rocks-Passage (Verankerung 259), 85 m Bodenabstand. Die Stromvektoren wurden gedreht, wie in Abb. 3 a gezeigt.

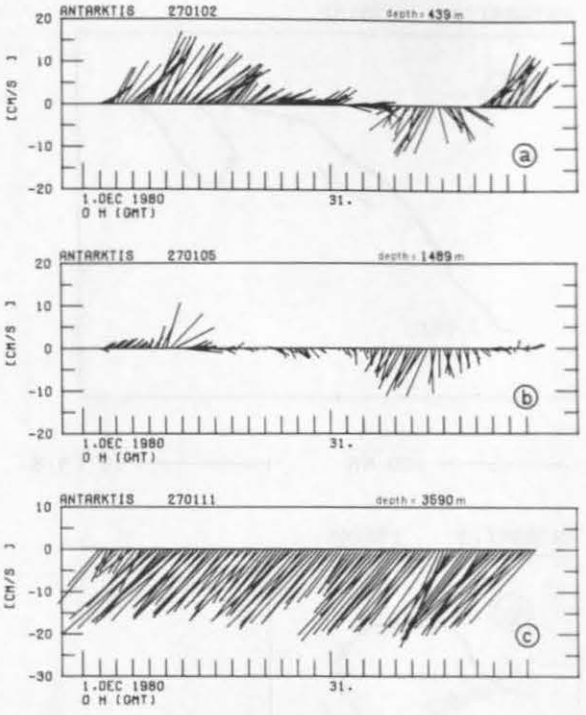

Fig. 6. Stick plot of 12-hourly averaged current vectors from the southern Drake Passage, north direction upwards. (a) 439 m, (b) 1489 m, (c) 3590 m depth.

Abb. 6. Vektorzeigerdiagramm der 12stündig gemittelten Daten aus der südlichen Drake-Straße. Die Nordrichtung zeigt nach oben. (a) 439 m, (b) 1489 m, (c) 3590 m Tiefe.

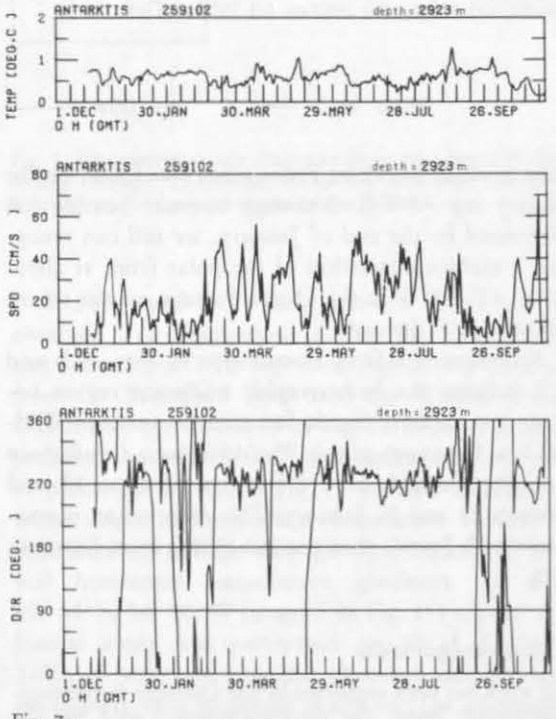

Fig. 7 a

Fig. 7. Temperature, current velocity and direction from the Shag Rocks Passage, mooring 259. Statistical properties of all time series are summarized in Table 1. (a) 85 m, (b) 35 m bottom clearance.

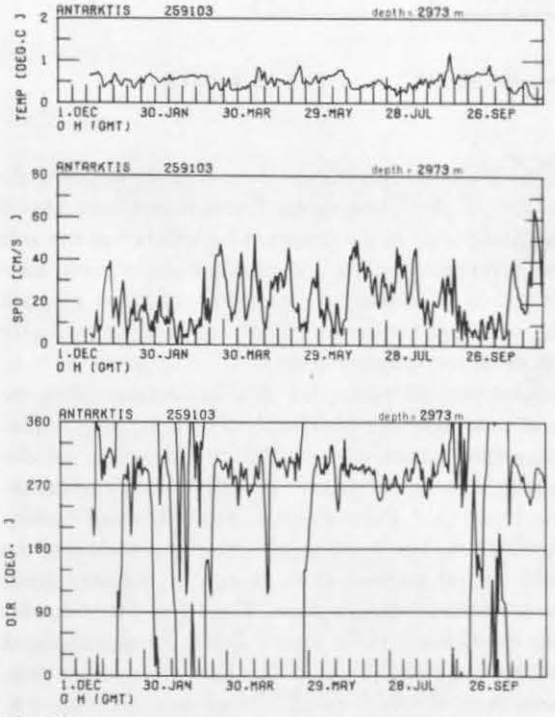

Fig. 7 b

Abb. 7. Temperatur, Stromgeschwindigkeit und -richtung aus der Shag Rocks-Passage, Verankerung 259. Die statistischen Eigenschaften aller Meßreihen sind in Tab. 1 zusammengefaßt. (a) 85 m, (b) 35 m Bodenabstand.

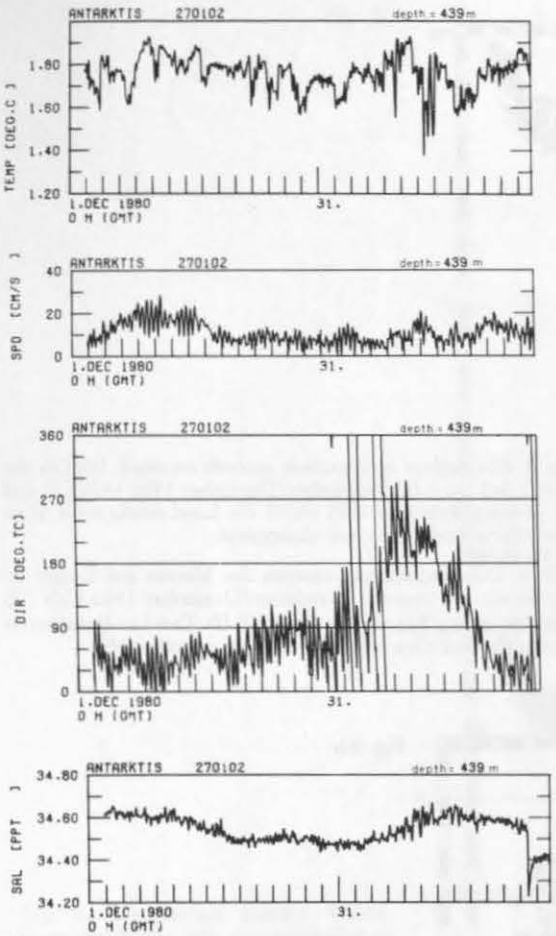

Fig. 8 a

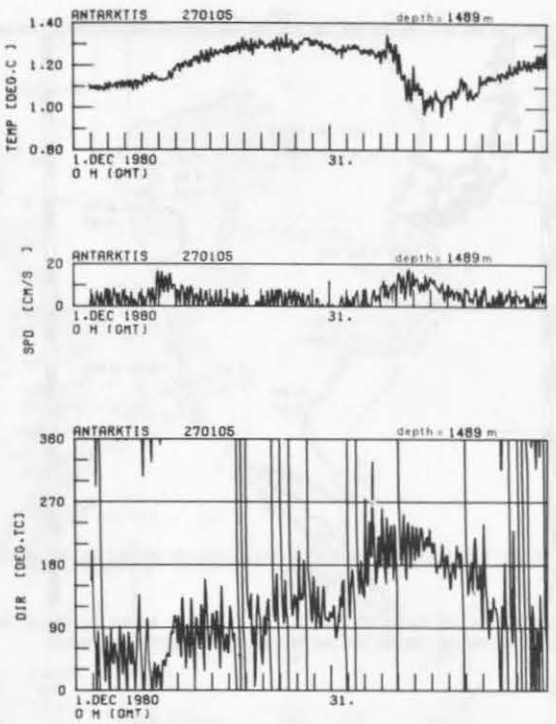

Fig. 8 b

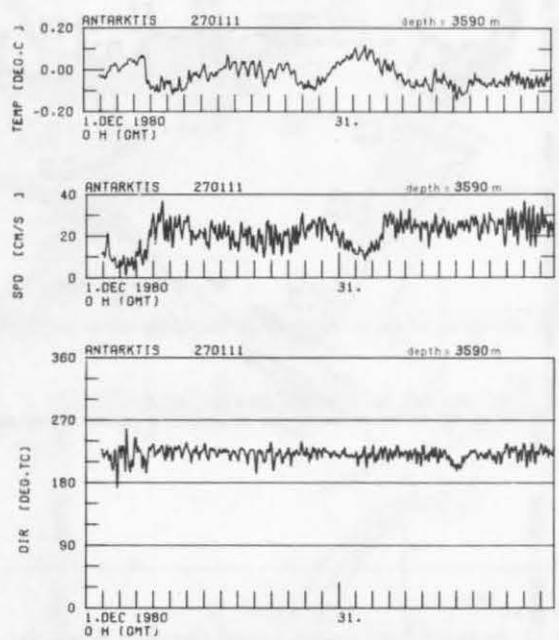

Fig. 8 c

Fig. 8. Temperature, salinity ([a] only), current speed and direction records from the southern Drake Passage, mooring 270. (a) 439 m, (b) 1489 m, (c) 3590 m depth. The absolute salinity values are uncertain.

Abb. 8. Temperatur, Salzgehalt (nur [a]), Strömungsgeschwindigkeit und -richtung aus der südlichen Drake-Straße, Verankerung 270. (a) 439 m, (b) 1489 m, (c) 3590 m Tiefe. Die absoluten Salzgehaltswerte sind ungewiß.

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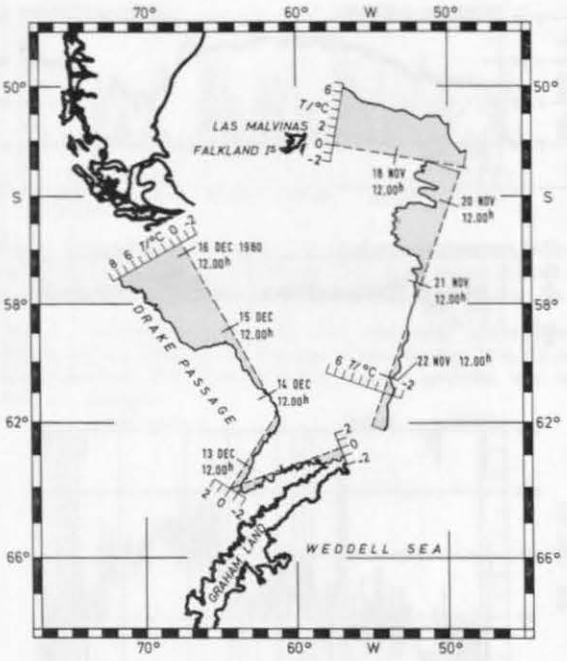

Fig. 9 a

Fig. 9. Sea surface temperature records on track lines in the Scotia Sea from (a) November/December 1980 (ANT I) and (b) January/February 1981 (ANT II). Land marks serve as an orientation only. They are incomplete.

Abb. 9. Oberflächentemperaturen des Meeres auf Kursen in der Scotia See vom (a) November/Dezember 1980 (ANT I) und (b) Januar/Februar 1981 (ANT II). Die Landkontouren dienen nur zur Orientierung. Sie sind unvollständig.

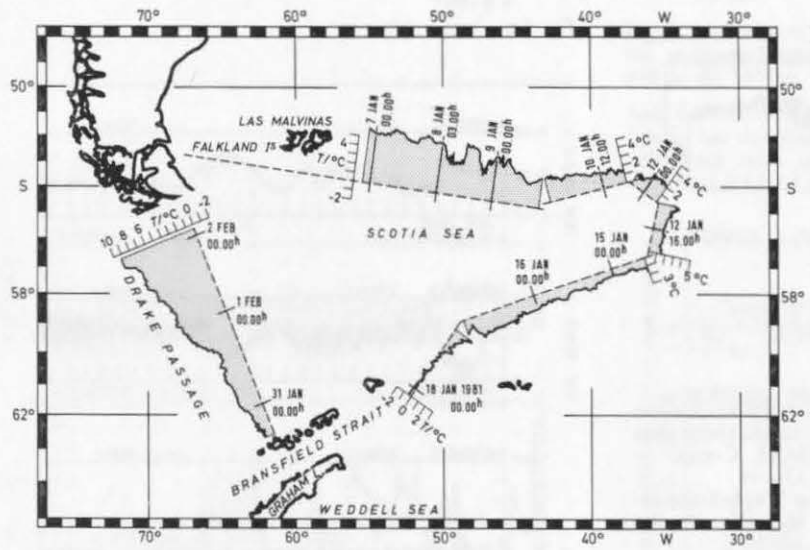

Fig. 9 b

See p. 86

Fig. 11. Surface salinity records from the southern Scotia Sea and the Bransfield Strait. Significant surface temperature range values were included. Due to technical problems finer scale temperature records were not obtained by the used thermosalinograph. Letter F marks the small scale investigation of a salinity front shown in Fig. 12 b. (a) November/December 1980, (b) January 1981.

See p. 85

Fig. 12. Small scale study of a surface salinity front of the Bransfield Strait: (a) bathymetry, (b) salinity distribution. The displayed discontinuity was observed for several times at the same location during the December operation of R.V. "Meteor" (cf. Fig. 11).

Abb. 11. Aufzeichnungen des Oberflächensalzgehaltes aus der südlichen Scotia See und der Bransfield-Straße. Typische Bereiche aufgetretener Oberflächentemperaturen sind ebenfalls dargestellt. Aufgrund von technischen Schwierigkeiten konnte eine hoch auflösende Temperaturmeßreihe mit dem benutzten Thermosalinographen nicht erhalten werden. Der Buchstabe F markiert die kleinräumige Untersuchung einer Salzgehaltsfront, welche in Abb. 12 b gezeigt wird. (a) November/Dezember 1980, (b) Januar 1981.

Abb. 12. Kleinräumige Studie einer Front im Oberflächensalzgehalt der Bransfield-Straße: (a) Bathymetrie, (b) Salzgehaltsverteilung. Die gezeigte Diskontinuität wurde mehrmals an derselben Stelle während der Arbeiten des F.S. „Meteor" im Dezember 1980 beobachtet (vgl. Abb. 11).

Fig. 10 a

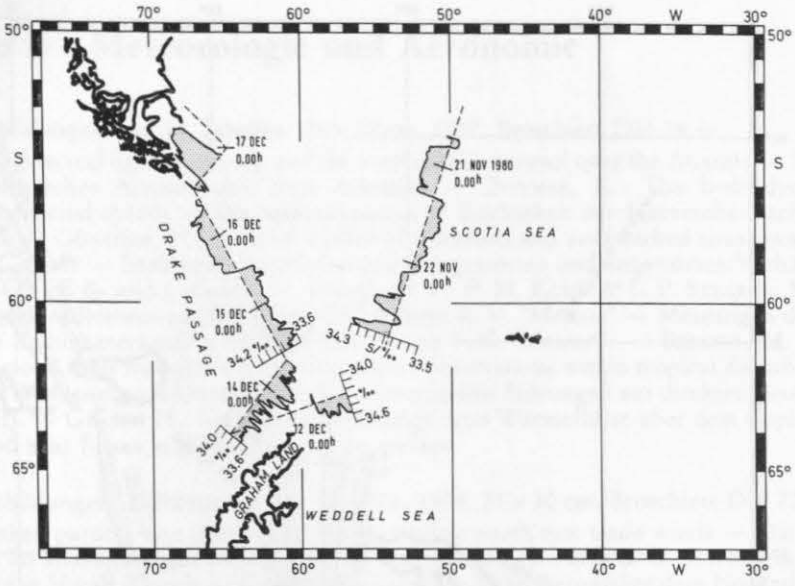

Fig. 10 b

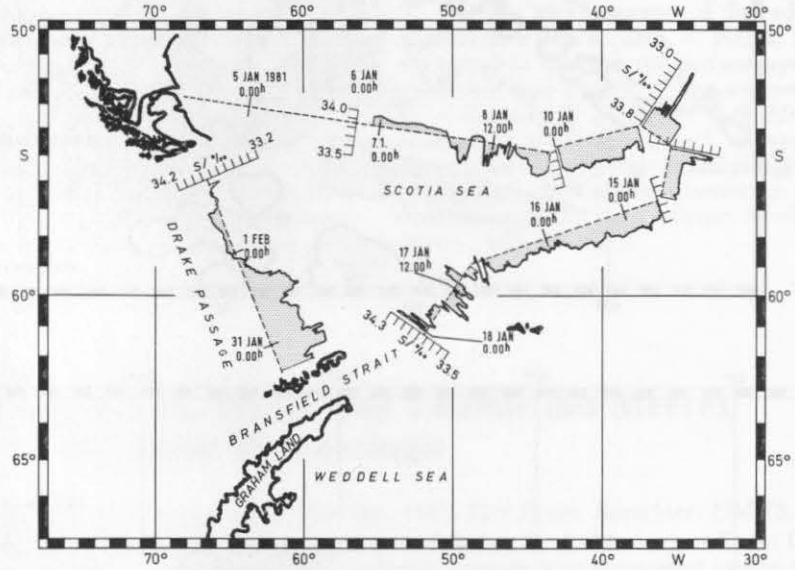

Fig. 10. Sea surface salinity records from the Scotia Sea, corresponding to temperature data from Fig. 9. (a) November/December 1980, (b) January/February 1981.

Abb. 10. Oberflächensalzgehalte des Meeres aus der Scotia See, entsprechend den Temperaturdaten in Abb. 9. (a) November/Dezember 1980, (b) Januar/Februar 1981.

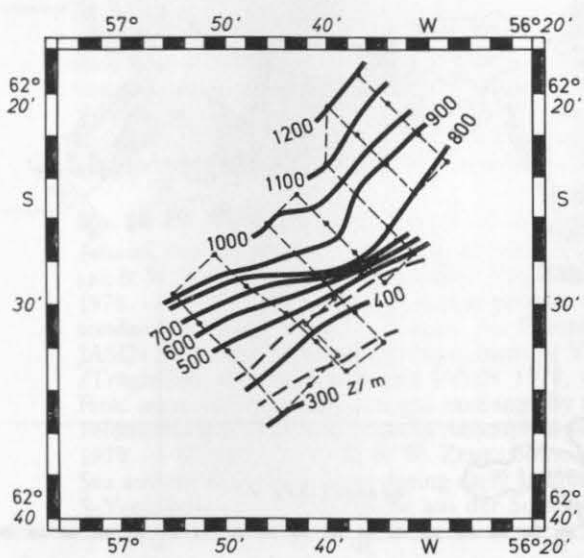

Fig. 12 a

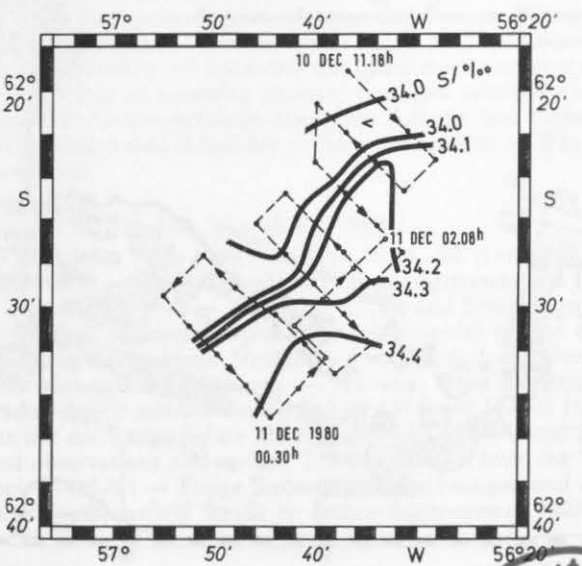

Fig. 12 b

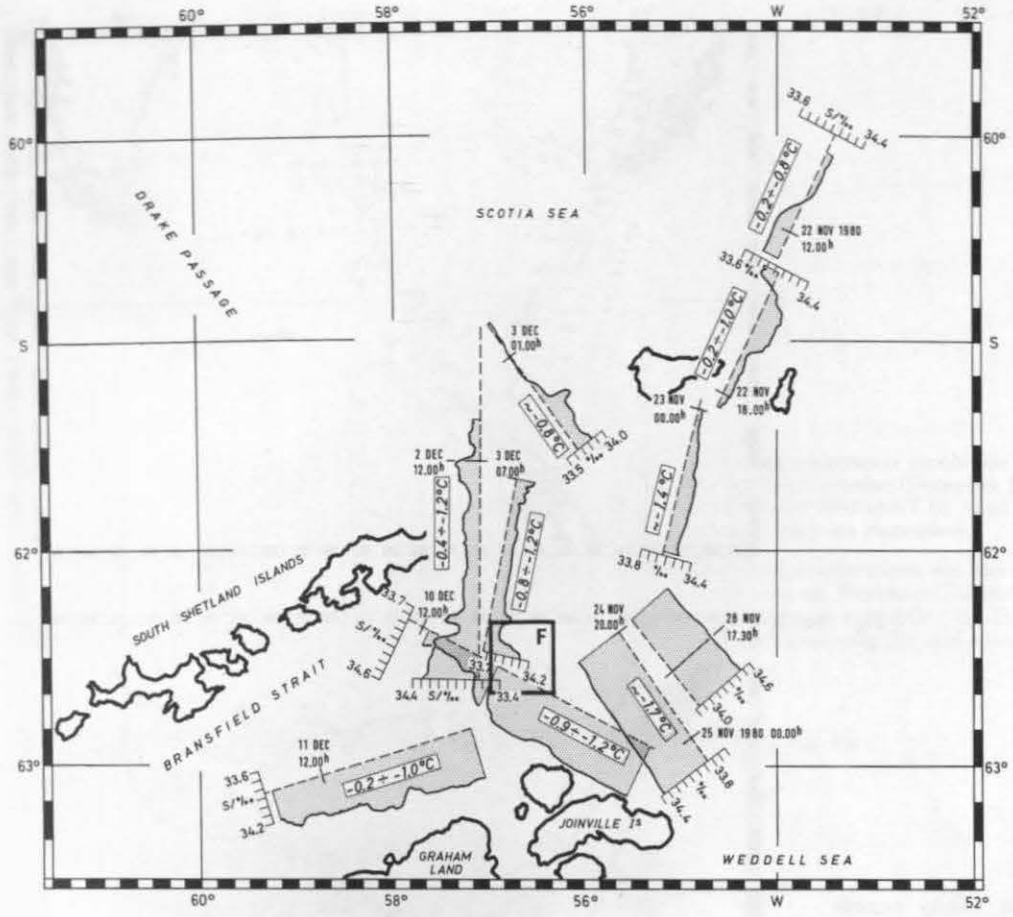

Fig. 11 a

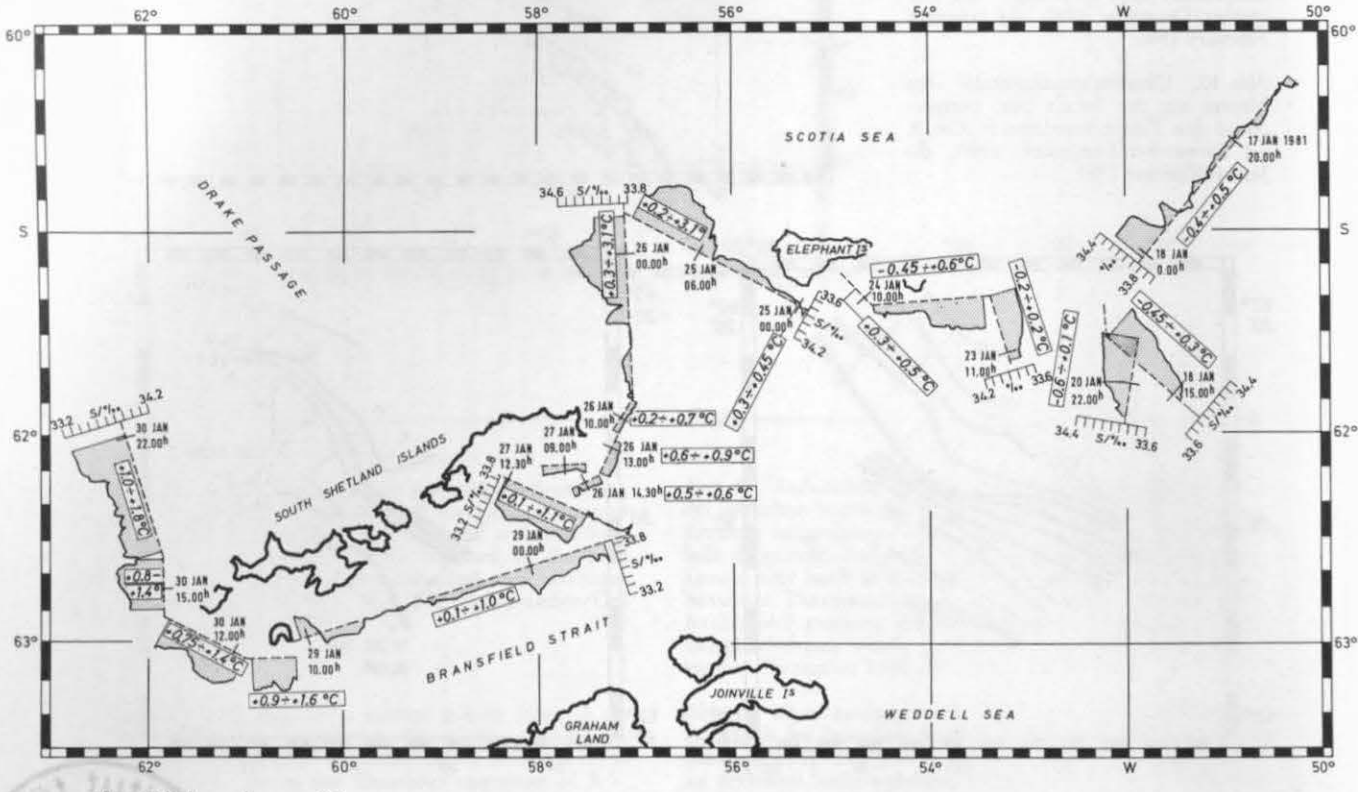

Fig. 11 b legend see p. 84